94th Session A: 5G, internet of things (IoT), and over the air (OTA) measurement & calibration-

Session Chair: Rusty Myers

A1 **EM Simulation and Validation Challenges for 5G Systems (Invited Paper)**

1:10 PM 1:50 PM ***Peter Zampardi,*** *Scott Morris; John Orlowski ; Brian Moser,* Qorvo

5G systems, particularly those at higher frequencies (26 GHz-40 GHz), have gathered a great deal of attention. Most of this attention has focused on either the system side or the device technology side. However, for mobile applications, packaging is also a very important consideration and cost is a major factor. For example, most handset modules currently use laminate technologies which are inexpensive rather than what would be used for other infrastructure systems.
To design products, information about the laminates is put into an electro-magnetic simulation tool and used by designers to develop matching networks and other elements, for the module. For 5G, the antennas may be implemented on such substrates. While a great deal of physical information can be collected from the laminate supplier, the electrical data (dielectric constants, dielectric loss, metal roughness/loss, etc) does not usually represent what designers need. In this talk, we will highlight the information needed to successfully simulate laminates and discuss some of the intricacies of laminate variation that make this challenging. It is hoped that this will open a dialogue for how we can develop standard extraction techniques that can be used to improve the simulation capability of these technologies the higher frequencies required for 5G systems.

A2 **OTA G/T Measurements of Active Phased Array Antennas using a Vector Network Analyzer**

1:50 PM 2:10 PM ***Joel Dunsmore,*** Keysight Technologies

G/T is a common figure of merit, which replaces noise figure for active antennas. An active antenna has both anten-na gain from the configuration of the elements as well as from ac-tive electronic amplification integrated with the antenna. The integration precludes measuring the noise figure of the active element directly. Active phased-array antennas have many elements, each contributing some noise (uncorrelated) and some signal (correlated). Traditional Y-factor (Hot/Cold) methods don't work well for active antennas; here is introduced a cold-source and calibration method that can measure both the gain of the antenna and the G/T, utilizing a Vector Network Analyzer with integrated noise figure measurement.

A3 **Using Active Load-Pull with Modulated Signals to Optimize Power and Linearity**

2:10 PM 2:30 PM *Xenofon Konstantinou (Michigan State University)*; John Albrecht (Michigan State University); John Papapolymerou (Michigan State University)*

Active Load-Pull (L-P) measurements using modulated signals are performed on a packaged GaN HEMT to optimize power and linearity. The measurements are taken using single-tone (1-tone), two-tone (2-tone), and modulated (128-QAM) signals at 2 GHz. A test fixture with a 6 W commercial GaN HEMT is used as the device-under-test (DUT). Linearity is optimized by minimizing IM3 and ACPR. Furthermore, a comparison of the optimized load power performance between 1-tone and 128-QAM is made. Our results show that the impedance matching conditions that optimize either power or linearity can be reliably predicted via active L-P using modulated signals. We also find that there are considerable differences between 1-tone and the modulated signals in the load power contours and optimal load power impedance matching conditions. These ascertainments could impact power amplifier design depending on the power and linearity specification trade-offs.